STUDY 1. EVALUATION OF THE STEP HATCHBOX (FRY RELEASE) PROGRAM

INTRODUCTION

Historical Background and Rationale for Hatchboxes

The use of coho salmon hatchery fry and fingerling to supplement wild populations has a long history in Oregon coastal streams. However, the evaluation of the success of these programs has been problematic, at best.

Juvenile coho salmon have been released into Oregon streams and rivers since about 1890 (Figure 1). Until 1910, all the fish released were unfed fry. Beginning in about 1910 an experiment was set up at Central Hatchery (now Bonneville) to evaluate the effects of pond rearing the fry to a larger size prior to release. Returns of adult fish between 1914 and 1919 were at or near historical levels suggesting that the new rearing strategy was successful. The first coastal releases began about 1890 by R.D. Hume on the Rogue River. His self-proclaimed success led to the development of 10 coastal hatcheries or egg taking stations by 1915. By 1938, over 30 million coho salmon fingerlings and fry were being released into Oregon coastal streams.

By the early 1940s, the first smolt releases (fish larger than 25 fish per pound) were beginning. As the number of smolts released began to increase the numbers of fry and fingerlings released began to decline. Several reasons have been cited for this decline. The major reason was that larger fish were shown to survive better than fingerlings or fry. Other reasons cited include a major advancement in disease control (pasteurized feed), nutrition, better broodstock development and improved hatchery practices.

During the 1960s and 1970s, the number of adults spawned exceeded the capacity of the available hatchery rearing space, and the excess offspring were released as unfed fry. During this period, the first attempt to evaluate the success of the fry-stocking program was completed. An analysis of the relationship between hatchery coho salmon fry releases and adult escapement (McGie 1980), for the 1961 through 1971 broods, suggested that the release of fry "had no measurable influence on adult escapement." Fry and fingerling releases subsequently began to decline.

In the early 1980s, a legislatively directed program of presmolt (200/lb) releases was initiated. An evaluation of this program (Nickelson et al. 1986) suggested that the increased number of fish released did not result in increased production of adults in the streams where the fingerlings were stocked. Because of this evaluation and decreased numbers of excess adult fish returning to coastal hatcheries the number of fry and fingerlings released in recent years has declined.

The Oregon Department of Fish and Wildlife began using hatchboxes on a large scale beginning in 1981 with the creation of the Salmon and Trout Enhancement Program (STEP). This program was begun under legislative directive (ORS 496.430 to 496.460). The goal of the STEP program is to restore

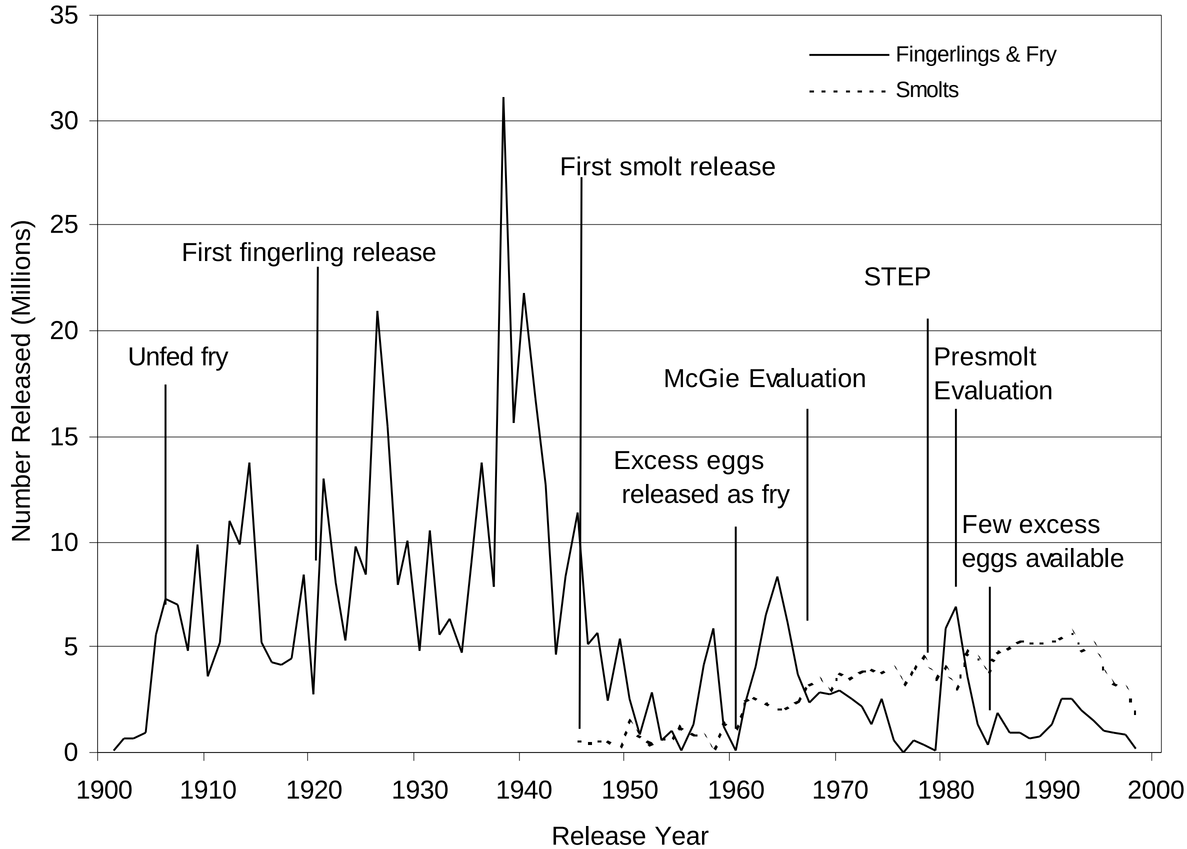

Figure 1. Coho salmon fry, fingerlings and smolts released into coastal streams since 1900.

native stocks of salmon and trout to their historic levels of abundance. One of the techniques used to achieve this goal has been the use of volunteers to raise excess eggs in hatchboxes. Several successful designs have been used, including one designed by ODFW personnel using a modified plastic bucket. The unfed fry are then released directly from the hatchbox or transported and released into local streams and rivers in an attempt to bolster depressed stocks. Approval by the Department of Fish and Wildlife for volunteers to obtain eggs from state hatcheries to incubate in hatchboxes is administered under OAR 635-09-090 to 635-09-140. Section one of this rule states that "all projects must comply with fish management goals and objectives as set forth in OAR 635-070-501 through 635-07-830, and species and/or area management plans adopted by the Commission." It further states that a project will NOT be approved if it is not based on sound biological principles and is not supported by physical and biological stream survey information or if it proposes to use inappropriate methods to accomplish the project objectives.

The Oregon Department of Fish and Wildlife will support the use of hatchboxes only in certain areas and under certain specific conditions. The areas where hatchboxes are most likely to be appropriate are streams historically inhabited by the juvenile fish of the species of interest, but where they are not now present. In some cases, hatchboxes are used in areas above artificial barriers that block passage of adult salmonids. Hatchboxes may be used to supplement existing populations only if information from a physical and biological survey of the stream suggests that the local population is extremely depressed and that there is sufficient habitat available to support the hatchbox fry without having a detrimental effect on the local population. Except for small projects that focus on education, release into a stream is limited to one life cycle of the species. Hatchboxes are an inappropriate tool in areas where the available rearing habitat is already fully occupied by juvenile salmonids, or where the appropriate egg source (brook stock) is not available.

Social interactions between hatchbox fry and native wild fry generally result in displacement of the hatchbox fry into marginal habitats where survival is low, however, some wild fry are also displaced. Evaluations of salmon fingerling releases (Nickelson et al. 1986) and fry releases (McGie 1980) suggest that the release of large numbers of fingerlings and fry into coastal streams does not result in increased adult production. Nickelson et al. (1986) documented a detrimental impact on wild adult coho salmon production from fingerling releases, partly because of the use of an inappropriate broodstock that spawned too early.

STEP Hatchbox Evaluation

During the early 1980s, we evaluated the effectiveness of using hatchery presmolts to rehabilitate naturally spawning coho salmon populations in coastal streams (Nickelson 1981; Nickelson et al. 1986; Solazzi et al. 1983, 1990). We found that the numbers of juvenile wild coho salmon were reduced in streams stocked with hatchery presmolts. We also found that, although the total number of spawners in stocked and unstocked streams were similar in the years that the hatchery fish returned, the late-spawning wild adults in the stocked streams were 50% less abundant than in the unstocked streams. We concluded that the hatchery presmolts reduced the wild populations through competition and that the early returning hatchery fish failed to contribute significant numbers of offspring to the next generation. Two factors contributed to this result: 1) early spawning time of the hatchery broodstock, and 2) large size of the presmolts relative to the wild fish.

The purpose of the STEP hatchbox evaluation program was to evaluate the effectiveness of coho salmon fry that result from late spawning broodstock incubated in STEP hatchboxes, to rehabilitate wild populations of coho salmon in the Siuslaw basin. The purpose of the otolith marking experiment was to determine the feasibility of mass marking coho salmon embryos by altering the incubation temperature.

METHODS

Fry Releases

During 1986 we obtained eggs from Coquille stock coho salmon spawned at Bandon Hatchery. Eggs were from two lots and were transferred from Bandon to the Lake Creek STEP facility in the Siuslaw basin on 6 and 13 March. Eggs were incubated at the STEP site in standard shallow hatchery trough 16 feet long. Each trough incubated six stacks of three egg trays. Trays measured 11 x 22 x 2-1/2 inches and each contained approximately 3,500 eggs. Flow to each trough was maintained at approximately 12 gallons/minute. Temperature ranged from 44° – 50° F. Fry were stocked in the treatment streams on 15 and 21 April. Each treatment stream was stocked on each date and an equal proportion of fry from each egg lot went into each treatment stream. The number of fry stocked in each treatment stream is shown in Table 1. Fry were stocked according to guidelines developed by ODFW (McGie 1986), which considered both stream area and the number of female spawners the previous winter.

During 1987 coho salmon eggs were obtained from Coos River stock coho salmon. Adults were spawned at Priorli Creek (Coos River). Eggs were first incubated at Bandon Hatchery and were then transferred to STEP hatching sites in the Siuslaw basin on 10 February, 13 February, and 4 March. Fry were released into the six treatment streams between 2 April and 13 April. Additional fry (58,880) were brought directly to the study streams from Priorli Creek to increase the stocking density to 4 fry/sq m of summer surface area. A total of 519,343 fry were stocked in the six treatment streams (Table 2).

Table 1. Results of sampling adult and juvenile coho salmon in 12 study streams. Spawning during winter 1985; fry stocked April 1986; density estimated during July-August 1986.

	Spawning Adults Per km.	Number of fry stocked	Average density (Juveniles/m^2)
Treatment			
Buck Cr.	17.8	3,758	0.07
Eames Cr.	0.0	41,090	0.10
Oxbow Cr.	21.8	9,320	0.13
Greenleaf Cr.	100.6	0	0.05
Green Cr.	13.0	26,558	0.29
Nelson Cr.	37.0	19,513	0.07
Reference			
Panther Cr.	96.5		0.39
Rogers Cr.	41.0		0.21
Misery Cr.	42.4		0.37
Dogwood Cr.	4.0		0.02
Billie Cr.	3.0		0.15
Doe Cr.	0.0		0.02

Because of the low numbers of spawners returning to the STEP spawning facility at Priorli Creek (Coos River) during the 1987-88 spawning season, and because of high mortality of fry at a STEP hatchbox facility in the Siuslaw basin, only 25,602 fry were available for stocking in the six treatment streams. Rather than stock fry at a low density in all six streams, we chose to stock one stream (Oxbow Creek) with all available fry to obtain a stocking density of 4 fry/ sq m.

Approximately 19,102 fry were stocked in Oxbow Creek on 4 April and 6,500 on 11 April 1988. Because we were able to stock only one of the treatment streams, we sampled the two control streams (Dogwood and Doe creeks) that are near Oxbow Creek for juvenile abundance (Table 3).

Table 2. Results of sampling adult and juvenile coho salmon in 12 study streams. Spawning during winter 1986; fry stocked April 1987; density estimated during July -August 1987.

	Spawning Adults Per km.	Number of fry stocked	Average density (Juveniles/m^2)
Treatment			
Buck Cr.	15.6	36,582	0.22
Eames Cr.	23.8	56,092	0.38
Oxbow Cr.	6.3	24,576	0.78
Greenleaf Cr.	20.6	157,020	0.70
Green Cr.	7.3	81,286	0.48
Nelson Cr.	8.9	163,787	0.18
Reference			
Panther Cr.	27.5		0.33
Rogers Cr.	6.3		0.33
Misery Cr.	5.6		0.46
Dogwood Cr.	15.6		0.30
Billie Cr.	6.3		0.30
Doe Cr.	110.0		0.46

Table 3. Results of sampling adult and juvenile coho salmon in 12 study streams. Spawning during winter 1987; fry stocked April 1988; density estimated during July-August 1988.

	Spawning Adults Per km.	Number of fry stocked	Average density (Juveniles/m^2)
Treatment			
Buck Cr.	7.8		
Eames Cr.	12.5		
Oxbow Cr.	8.1	25,602	0.35
Greenleaf Cr.	11.9		
Green Cr.	5.2		
Nelson Cr.	12.0		
Reference			
Panther Cr.	25.0		
Rogers Cr.	11.2		
Misery Cr.	3.1		
Dogwood Cr.	3.8		0.21
Billie Cr.	4.4		
Doe Cr.	15.6		0.24

To determine the fate of released hatchbox fry; we also estimated the number of planted fry that left Oxbow Creek immediately after stocking. On 1 April 1988 we marked with a small, upper caudal fin clip 11,078 of the 19,102 fry (58%) that made up the first group to be released in Oxbow Creek. Marked fry were returned to the hatchbox and allowed to mix with the unmarked fry. On 4 April we placed a floating scoop trap with 2-ft-wide screen near the mouth of Oxbow Creek. After the trap was in place we divided the 19,102 fry into four approximately equal groups and released them at four different locations from 0.5 to 2.0 km above the trap in Oxbow Creek. Each evening of the study we released a known number of fin clipped (lower caudal) or branded fry into the stream a short distance above the trap. Because day-to-day estimates of trap efficiency ranged from 2.0% to 29.3% we also estimated trap efficiency as a total for the 4 days.

Adult Surveys

The number of adult coho salmon spawners using the treatment and control streams was estimated by foot surveys and area-under-the-curve (AUC) methodology (Biedler and Nickelson 1980; Neilson and Geen 1981; Solazzi 1984). Total numbers of spawners was estimated by dividing AUC fish-days by an average residence time of 11.3 days/fish (Willis 1954; Biedler and Nickelson 1980). Estimated spawners were then divided by the length of the survey reach (a fraction of the total stream length) to express density as spawners per kilometer. Comparisons of adult abundance in treatment and control streams were made using an analysis of variance.

Density of Juveniles

The density of juvenile coho salmon in the 12 study streams was estimated during August each year. Each study stream was sampled in a lower, middle, and upper unit. In the stocked streams these units were located at approximately 20%, 50%, and 80% of the distance from the mouth to the uppermost stocking site. In the unstocked streams these units were located at points 20%, 50% and 80% of the distance from the mouth to the upper limits of coho salmon distribution. Each unit consisted of five consecutive pools. Pool lengths and widths were measure to the nearest meter and tenth of a meter, respectively. Pool depth measurements (nearest centimeter) were taken at points ¼, ½, and ¾ of the distance across each width transect. Length, width, and depth data were used to calculate the surface area and volume of each pool. A catch and removal estimate (Seber and LeCren 1967) was made in each pool. Blocking seines were placed at the upper and lower boundaries of each pool and fish were removed by seining, electrofishing, or both. Two to four passes were used to remove the fish from each pool with the goal being to achieve confidence limits not greater 10% of the mean estimate in each pool. The population estimates for coho salmon in each unit were divided by the pool surface area of the unit to determine density as the number of coho salmon per square meter of surface area in each pool.

Otolith Marking

We received approximately 15 thousand eyed coho salmon eggs from Bandon Hatchery on 19 February 1990. These eggs were from fish spawned at Bandon Hatchery on 16 January 1990. We divided the eggs into three approximately equal groups (A, B, and C) and placed each group into a separate incubator tray at the Corvallis Research Laboratory. Well water at the rate of approximately 4 gallons per minute was supplied to each incubation tray. Ambient water temperature varied between 10.5° and 12°C. Group A was assigned as the control group and groups B and C were the treatment groups. Group A received ambient well water throughout the experiment. On 23 and 27 February and again on 5, 9, 13, 21, and 27 March, group B was exposed to chilled well water (between 4° and 5°C) for 6 h. Group C was exposed to the chilled well water on 27 February and on 9 and 21 March, also for 6 h each time.

On 10 April a sample of approximately 25 fry from each group was removed from the incubators and preserved in 80% ethanol. A labeled sample of each group (ten fish per group) and a sample containing an "unknown" mixture of the three groups (5 fish total) was sent to Eric Volk (Washington Department of Fisheries, Olympia, Washington) for analysis and identification. The otoliths were removed from the fish, sectioned, polished, and examined under a microscope (200x).

RESULTS AND DISCUSSION

Adult Abundance

The number of adult coho salmon returning to the study streams during 1985-1987 was not significantly different between the treatment and reference streams (ANOVA; p=0.54). Because there was no difference in adult abundance between the reference and control streams, any differences in juvenile abundance should be due to the effects of stocking the hatchbox fry.

Juvenile Density

We did not find an increase in juvenile coho salmon density as a result of stocking hatchbox fry for two years in the six study streams (ANOVA; p=0.89). Results from each year of sampling are presented in Tables 1-3.

The number of fry captured by the floating scoop trap in Oxbox Creek is shown in Table 4. The estimated total number of outmigrant fry was 5,048 when we summed day-to-day estimates of trap efficiency, and 2,388 when we used overall trap efficiency estimates (total recaptures/total marks) (Table 4). The estimated percentage of the total number of fry released that migrated past the trap during the first 4 days after release was 26.4% and 12.5%, respectively, using the two methods.

Table 4. Estimated number of STEP coho salmon fry that migrated from Oxbow Creek in the first 4 days after stocking. An estimated 19,102 fry were released on 4 April 1988.

Date	Number of marked fry released	Percentage of marked fry recaptured	Number of STEP fry captured	Estimated number of STEP fry that migrated
4-April	51	--	--	--
5-April	75	5.88	279	4,745
6-April	45	29.30	47	160
7-April	100	32.00	5	16
8-April	--	2.00	1	50

Results from sampling juvenile coho abundance and outmigration suggest that the hatchbox program was not effective at increasing the rearing density of juvenile coho salmon in the treatment streams. Our estimates suggest that 13%-26% of the juvenile coho salmon fry stocked in Oxbow Creek migrated out of the stream within four days after stocking.

Otolith Marking

By rapidly dropping the incubation temperature we caused distinctive dark bands (tightly packed circuli) to form on the otoliths of developing coho salmon embryos. The “unknown” sample was correctly identified as containing 2 fish from groups A and B and one fish from group C. This technique could be used to mark juvenile coho salmon while they are incubating in hatchboxes and allow for subsequent identification of returning adults. A distinctive pattern could be produced for each hatchbox location, thus forming a basis for determining the contribution of each hatchbox to adult coho salmon production.

Summary

There is little argument that good artificial incubation techniques can have egg-to-fry survival rates of well over 95%, a significant increase over values reported for naturally incubated eggs. However, there is little evidence that egg-to-fry survival rates are limiting the adult production of most salmonid fishes. One exception to this may be with chum salmon, which migrate into salt-water almost immediately after emerging from the gravel. For salmonid species with extended freshwater rearing (coho, steelhead, cutthroat and some chinook stocks) factors other than egg to fry survival rate are probably more important in determining adult production levels. Recent studies by Nickelson et al. (1992) for coho salmon in Oregon coastal streams suggest that winter habitat may often be the limiting factor in the freshwater environment, especially for juvenile coho salmon.

LITERATURE CITED

Biedler, W. M., and Nickelson, T.E. 1980. An evaluation of the Oregon Department of Fish and Wildlife standard spawning fish survey system for coho salmon. Oreg. Dept. Fish. Wildl., Fish Div. Info. Rep. 80-9, Portland.

McGie, A. M. 1980. Analysis of relationships between hatchery coho salmon transplants and adult escapements in Oregon coastal watersheds. Oreg. Dept. Fish. Wildl., Fish Div. Info. Rep. 80-6. Portland.

McGie, A.M. 1986. Guidelines for stocking salmonids in streams. Oreg. Dept. Fish. Wildl. Processed Report. Portland.

Neilson, J.D. and Geen, G.H. 1981. Enumeration of spawning salmon from spawner residence time and aerial counts. Trans. Am. Fish. Soc. 110:554-556.

Nickelson, T.E. 1981. Coho presmolt program for Oregon coastal streams. Oreg. Dept. Fish. Wildl., Fish Div. Info. Rep. 81-1, Portland.

Nickelson, T. E.. M. F. Solazzi, and S. L. Johnson. 1986. Use of hatchery coho salmon *Oncorhynchus kisutch* to rebuild wild populations in Oregon coastal streams. Can. J. Fish. Aquat. Sci. 43: 2443-2449.

Nickelson, T. E., J. D. Rodgers, S. L. Johnson, and M. F. Solazzi. 1992. Seasonal changes in habitat use by juvenile coho salmon *Oncorhynchus kisutch* in Oregon coastal streams. Can. J. Fish. Aquat. Sci. 49: 783-789.

Seber, G.A.F. and LeCren, 1967. Estimating population parameters from catches large relative to the populations. Jl. An. Ecol. 35:631-643.

Solazzi, M.F. 1984. Relationships between visual counts of coho, chinook, and chum salmon from spawning fish surveys and the actual number of fish present. Oreg. Dept. Fish. Wildl., Fish Div. Info. Rep. 84-7, Portland.

Solazzi, M.F., S.L. Johnson, T.E. Nickelson. 1983. The effectiveness of stocking hatchery coho salmon presmolts to increase the rearing density of juvenile coho salmon in Oregon coastal streams. Oreg. Dept. Fish. Wildl., Fish Div. Info. Rep. 83-1, Portland.

Solazzi, M.F., S.L. Johnson, T.E. Nickelson. 1990. An evaluation of the use of coho salmon presmolts to supplement wild production in Oregon coastal streams. Oreg. Dept. Fish. Wildl., Fish Div. Res. Rep.No. 10, Portland.

Willis, R.A. 1954. Experiments with repeated spawning ground counts of coho salmon in three Oregon streams. Fish Comm. Oreg. Res. Briefs 10(1):41-45.